

INDOOR AIR QUALITY ASSESSMENT

**Manchester Memorial Elementary School
43 Lincoln Street
Manchester, Massachusetts**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
September 2004

Background/Introduction

At the request of Roger Young, Business Manager, Manchester Essex Regional School District, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Manchester Memorial Elementary School (MMES), 43 Lincoln Street, Manchester-by-the-Sea, Massachusetts. On March 7, 2004, a visit to conduct an indoor air quality assessment was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA. Mr. Feeney was accompanied by Sharon Lee, Environmental Analyst, ER/IAQ during the assessment. Reports of inadequate ventilation, odors, lack of temperature control and other indoor air quality issues prompted the assessment.

The MMES consists of two separate buildings: the main building and the library or annex. These buildings were constructed from 1951 to 1952. The main building is the subject of this report; the annex is the subject of a separate report. The main building consists of six distinct wings, five (B, C, D, E, and F) of which appear to be part of the original building (Picture 1). Considering the ventilation system, wing A appears to have been constructed at a later date. Wings B and D are one story wings with a flat roof system. Wing C contains the gymnasium/cafeteria. Wings E and F are one-story wings with a roof/skylight system (Picture 2). Single-paned classroom windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEHA staff also performed visual inspection of building materials for water damage and/or microbial growth.

Results

The school complex houses approximately 400 kindergarten through sixth grade students and a staff of approximately 30. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in five of thirty-four areas surveyed, indicating inadequate air exchange in some areas. It is important to note that a number of areas were empty or sparsely populated at the time of the assessment, which can greatly reduce carbon dioxide levels. Of note was classroom 11, which had carbon dioxide levels above 800 ppm while unoccupied, further indicating poor air exchange.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. A univent draws air from outdoors through a fresh air intake located on the exterior wall of

the building and returns air through an air intake located at the base of the unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were operating in classrooms throughout the school at the time of the assessment. Obstructions to airflow, such as desks and other items located in front of univents were observed in several areas. To function as designed, univents must be allowed to operate and remain free of obstructions.

The school has two different types of exhaust ventilation systems. Exhaust ventilation is provided to classrooms in wing A by ducted, grated vents equipped with pull chains that adjust a flue in the ductwork (Picture 3). Some exhausts in wing A are located near hallway doors that can be blocked when doors are open. Exhaust ventilation in the other wings is provided by cabinet-mounted exhaust vents (Picture 4). Motorized fans draw air through grilles on cabinets and direct air below ground through ductwork out of the building via subterranean grates (Picture 5). Exhaust vents were drawing weakly or blocked with materials in a number of classrooms surveyed. As with univents, exhaust vents must be allowed to operate and remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see [Appendix A](#).

The temperature measurements ranged from 69° F to 78° F, which were very close to the BEHA recommended comfort guidelines (Table 1). The BEHA recommends that

indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents obstructed).

The relative humidity measured ranged from 18 to 28 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. It is important to note that relative humidity measured in some indoor areas exceeded outdoor measurements by as much as 9 percent. This increase in relative humidity can indicate that the exhaust system alone is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases. This relationship between temperature and relative humidity is known as the heat index. As indoor temperatures rise, increases in relative humidity will make occupants feel warmer. If moisture is removed, individuals feel more comfortable. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles that were evidence of historic leaks through the skylight system. Water-damaged ceiling tiles can provide a source of

mold growth. Water-damaged ceiling tiles should be replaced after a water leak is discovered and repaired. The school has a ceiling tile system where tiles are glued directly to the ceiling/walls (Picture 6). Replacement of these ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile. Appropriate measures should be taken to minimize the aerosolization of particulates from tile removal/replacement.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

An exit to the playground is located between wings D and E. A protective wood barrier was erected over the hallway window frame in this area. A significant amount of leaves had accumulated between the barrier and window frame (Picture 7). Under certain weather conditions, these leaves can become moistened and hold moisture against the window frame, providing a source for water penetration. In addition, leaves can be a mold growth medium.

At the time of the assessment, the school was not equipped with a gutter/downspout system. It appears that the original gutter/downspout system was removed. Areas along the roof soffit had spots of dissimilar/missing paint and nail holes in an evenly spaced pattern that were likely where gutter brackets were located (Picture 8). In addition, drainage pipes in the tarmac, similar to downspout drains observed by BEHA staff at other schools, were seen at the corners of some MMES wings (Picture 9). Without downspouts/gutters, water accumulates along the exterior walls of the building,

leading to water penetration through the subterranean exhaust vents and/or through exterior classroom doors.

Of note was carpeting installed against the threshold of exterior doors in some classrooms (Picture 10). Wall-to-wall carpet installed around the threshold may become regularly moistened, typically during wind-driven rain or drifting snow. Roof/shelter systems that exist over exterior doors can also contribute to the moistening of carpet. Rainwater collecting on these shelters rolls off and collects at the base of the building. This design is problematic due to tarmac/cement slabs used as exterior door thresholds. Splashing rainwater can lead to chronic moistening of the exterior wall and doors, which in turn moistens carpet installed against the doorframe. Mold colonization of the carpet can occur from repeated moistening.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that carpeting be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If carpets are not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

Other Concerns

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less

(PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 27 $\mu\text{g}/\text{m}^3$ (Table 1). PM2.5 levels measured indoors were in a range of 2 to 73 $\mu\text{g}/\text{m}^3$. The highest measurement of 73 $\mu\text{g}/\text{m}^3$ was taken in the gymnasium. This measurement can be attributed to the use of the gymnasium without activation of the mechanical ventilation system. Use of the gym aerosolizes dust. Operation of the ventilation system would reduce PM2.5 concentration, since the supply system introduces fresh air to dilute the space and the exhaust system removes particulates. Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that

occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND, with the exception of the exam room (0.4 ppm) (Table 1). The measurable level of TVOCs in this room was attributed to the use and storage of TVOC-containing cleaners. Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products.

Several other conditions that can affect indoor air quality were noted during the assessment. Univents are normally equipped with filters that strain particulates from airflow. The univent filters at the MMES provide minimal filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to

remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by increased resistance (called pressure drop). Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

Several pathways exist for air in the wall space to migrate into occupied areas. A crawlspace located beneath classrooms functions as a chase-way for univent heating pipes. BEHA staff randomly examined a number of univent interiors. Spaces and holes were observed around pipes and within the air handling cabinets (Picture 11). Spaces were also noted in the rear wall of univent cabinets (Picture 12). The existence of these holes allows for air to by-pass the filters, resulting in aerosolization of materials (e.g., dust) to the classrooms. These breaches can also serve as pathways for air, odors and particulates to be drawn from exterior wall cavities into classrooms.

Of note was the use of food for student art projects (Picture 13). Exposed food products and reused food containers can attract a variety of pests. The presence of pests inside a building can produce conditions that can degrade indoor air quality. For example, rodent infestation can result in indoor air quality related symptoms due to materials in their wastes. Mouse urine is known to contain a protein that is a known sensitizer (US EPA, 1992). A sensitizer is a material that can produce symptoms in exposed individuals, including nose irritations and skin rashes. Pest attractants should be reduced/eliminated. Proper food storage is an integral component in maintaining indoor

air quality. Food should be properly stored and clearly labeled. Reuse of food containers (e.g., for art projects) is not recommended since food residue adhering to the container surface may serve to attract pests.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were seen on windowsills, tabletops, counters, bookcases and desks. The amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate and make it difficult for custodial staff to clean.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Remove leaves from subterranean exhaust vent pits.
5. Consult a ventilation engineer concerning re-balancing of the ventilation systems and the calibration of univent fresh air control dampers throughout the school.

Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

6. Examine the feasibility of installing a gutter/downspout system on the roof.
7. Identify and repair sources of water leaks (e.g., window frames and roof). Replace water-damaged ceiling tiles. These ceiling tiles can be a source of microbial growth. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.
8. Remove carpeting up to three feet from the threshold of exterior doors. Replace carpeting with a non-slip, nonporous material (e.g., rubber matting, tile).
9. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Consider reducing the number of plants in certain classrooms.
10. Examine the feasibility of increasing HVAC filter efficiency. Note that prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.
11. Seal all holes in the walls at rear of univents as well as those in the univent air handling cabinets to limit filter bypass. Double sided, foil faced insulation with adhesive can be applied in a manner to create an airtight seal. Remove carpet from univent utility cabinets.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Consider adopting the US EPA document, *Tools for Schools* (US EPA, 2000b), as a means to maintaining a good indoor air quality environment in the building. This

document can be downloaded from the Internet at

<http://www.epa.gov/iaq/schools/index.html>.

14. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website:

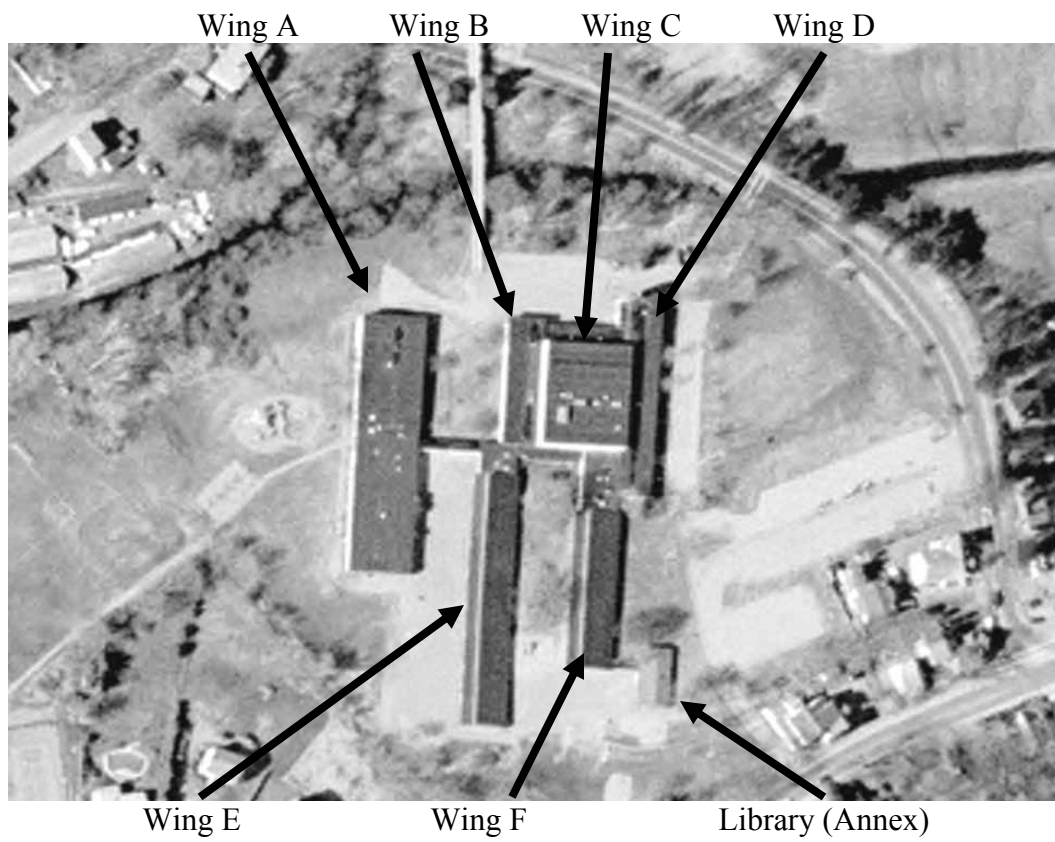
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Picture 1



Manchester Memorial Elementary School (MMES)

Picture 2



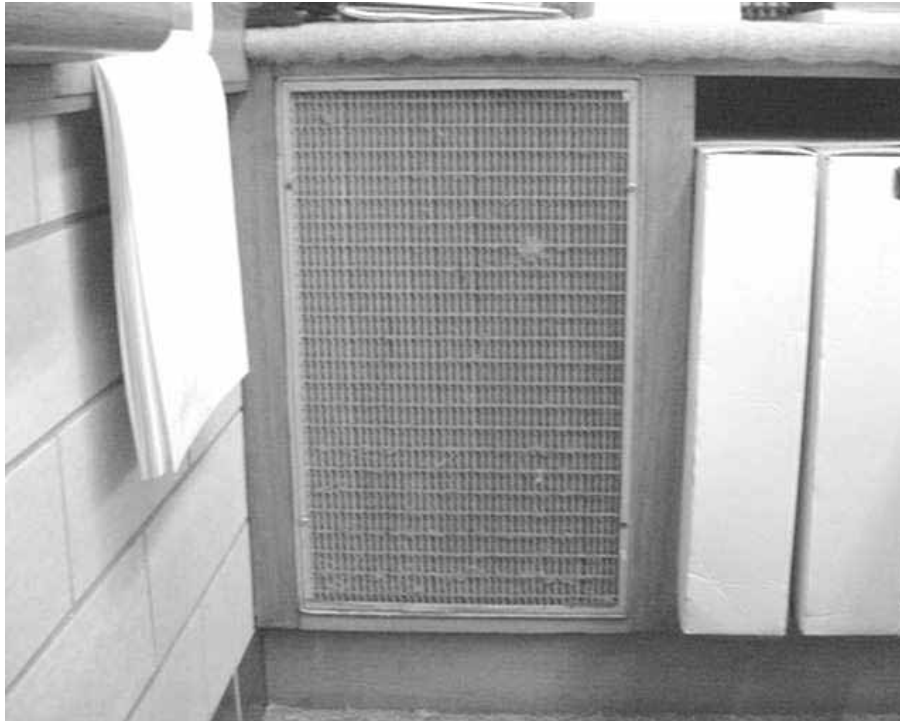
One-Story Wings With a Roof/Skylight System

Picture 3



Exhaust Ventilation Provided by Ducted, Grated Vents Equipped With Pull Chains to Adjust Flue Located in the Ductwork

Picture 4



Exhausts Grill Installed in a Cabinet

Picture 5



Below Grade Exhaust Vent in a Subterranean Pit

Picture 6



Interlocking Ceiling Tiles

Picture 7



A Significant Amount of Leaves Has Accumulated Between the Barrier and Window Frame

Picture 8



Roof Soffit with Dissimilar/Missing Paint in an Evenly Spaced Pattern With Nail Holes, Which Is Likely the Location of the Gutter Brackets

Picture 9



Pipes at Base of Wing That Formerly Drained Downspouts

Picture 10



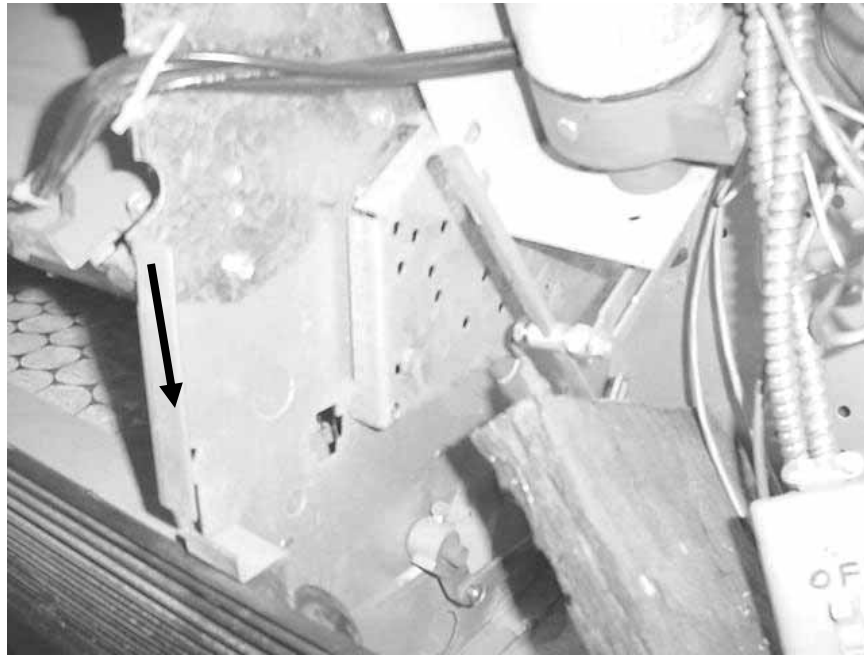
Carpeting Installed Against the Threshold of Exterior Doors

Picture 11



Spaces in Rear Wall of Air Handling Cabinet

Picture 12



Hole in Wall of Univent Air Handling Cabinets

Picture 13



Use of Food as Student Art Supplies

Memorial Elementary School
43 Lincoln Street, Manchester MA

Table 1

Indoor Air Results
March 7, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	67	19	410	ND	ND	27			-	-	Growth
25	70	20	512	ND	ND	25	0	Y	Y Univent	Y Wall	CD, Cleaners, plants, rubber cement, Hallway door open, exhaust blocked by dirt/debris, furniture and door
23	70	21	531	ND	ND	28	1	Y	Y Univent	Y Wall	DEM, cleaners, hallway door open, supply blocked by furniture, exhaust blocked by dirt/debris and door
24	74	21	909	ND	ND	46	19		Y Univent	Y Wall	Musty odor, DEM, hallway door open, supply blocked by boxes, exhaust blocked by door
14	75	21	579	ND	ND	32	2	Y			PC, UP, laminator, plants, Risograph X2, soda machine on carpet
22	73	19	568	ND	ND	25	0		Y Univent	Y wall	Breach sink/counter, DEM, hallway door open, supply blocked by furniture, exhaust blocked by door

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Memorial Elementary School
43 Lincoln Street, Manchester MA

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Indoor Air Results
March 7, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
27	69	21	523	ND	ND	22	0	Y	Y Univent	Y Wall	Cleaners, items on CT, hallway door open, supply blocked by clutter, furniture; exhaust blocked by clutter
21	70	22	640	ND	ND	26	0		Y Univent	Y Wall	CD, cleaners, exhaust blocked by clutter, dirt/debris, furniture
Exam room	69	24	724	ND	0.4	25	3	Y	N	Y-off	Cleaners, plants, hallway door open, window-mounted AC, exhaust undercut doors
26	70	21	555	ND	ND	21	0	Y	Y Univent	Y Wall	CD, PF, terra, cleaners, FC re-use, plants, hallway door open, supply blocked by clutter, furniture, exhaust occluded by dirt/debris
19	71	21	607	ND	ND	22	4		Y Univent	Y Wall	1 missing CT, DEM, cleaners, clutter, subdivided by book-shelves, supply blocked by clutter, window-mounted AC, exhaust occluded by, dirt/debris
17 Music	71	23	852	ND	ND	28	20	Y	Y Univent	Y Wall	CD, DEM, exhaust blocked by dirt/debris, furniture

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									Supply	Exhaust	
13 OT/PT Room	70	19	490	ND	ND	16	1	Y	Y Univent	Y Wall-off	CD, PF, cleaners, exhaust blocked by boxes
11	71	25	939	ND	ND	16	0		Y Univent	Y Wall off	CD, cleaners, items on CT, plants, hallway door open,
16	70	24	972	ND	ND	38	19		Y Univent	Y Closet	MT/AT x2, food use/storage, permanent markers
18	71	23	711	ND	ND	40	17		Y Univent	Y Closet	Breach sink/counter, DEM, PF, supply blocked by clutter
12	72	19	667	ND	ND	21	2		Y Univent	Y Wall	DEM, cleaners, supply blocked by boxes, clutter, exhaust blocked
10	71	22	595	ND	ND	31	0		Y Univent	Y Wall-off	Cleaners, hallway door open
9	70	19	469	ND	ND	17	2	Y	Y Univent	Y Off	CD, DEM, cleaners, FC re-use, supply blocked by clutter

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> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Memorial Elementary School
43 Lincoln Street, Manchester MA

Table 1

Indoor Air Results
March 7, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
7	71	19	548	ND	ND	18	3	Y	Y Univent	Y Wall-off	CD, cleaners, supply blocked by clutter, exhaust occluded by dirt/debris
6	72	18	539	ND	ND	18	2	Y	Y Univent	Y Wall	Cleaners, food use/storage, plants, hallway door open
15	70	20	533	ND	ND	20	7	Y	Y Univent	Y Closet	CD, exhaust blocked by boxes, clutter
8	72	20	525	ND	ND	28	0		Y Univent	Y Wall	Breach sink/counter, aqua, plants, pine cones, supply blocked by furniture, exhaust blocked by furniture
Computer Room	78	21	654	ND	ND	56	2		Y Univent	Y Wall	5 water damaged CT, 2 MT, plants, hallway door open, 26 computers
Auditorium	71	23	511	ND	ND	39	0		Y Wall	Y Wall	Hallway door open
20	71	24	591	ND	ND	51	18		Y Univent	Y Closet	DEM, cleaners, clutter, food use/storage/ hallway door open

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

WP = wall plaster

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									Supply	Exhaust	
4	77	22	771	ND	ND	28	0		Y Univent	Y-off	DEM, cleaners, hallway door open, bathroom
2	76	22	731	ND	ND		18	Y	Y Univent	Y Wall	Aqua, cleaners, clutter, plants, hallway door open, supply blocked by crayons, plants, umbrellas, exhaust blocked by boxes
Cafeteria	74	22	680	ND	ND	33	50+		Y Univent	Y	Exhaust-kitchen vents
Gym	73	21	645	ND	ND	73	20+		Y Wall-off	Y Wall-off	
1	69	22	573	ND	ND	18	0	Y	Y Univent	Y Wall	AD, FC re-use, plants, hallway door open, supply blocked by supply, exhaust blocked by door
Nurses' Main	69	24	634	ND	ND	20	0				Hallway door open

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									Supply	Exhaust	
5	70	28	754	ND	ND	24	17	Y	Y Univent	Y Wall	AD, CD, cleaners, items on ceiling, plants, supply blocked by clutter, dirt/debris, plants, exhaust occluded by dirt/debris
3	71	25	818	ND	ND	22	21	Y	Y Univent	Y Wall	CD, cleaners, items on ceiling, plants, pine odor, supply blocked by clutter, dirt/debris, plants, exhaust occluded by dirt/debris
Principal's Office	71	23	699	ND	ND	2	1		Y Ceiling	Y Ceiling	Inter-room door open

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